STRATEGIES TO ADDRESS CONTAMINATED SEDIMENTS

Testimony to

The Water Resources And Environment Subcommittee

of The Committee on Transportation and Infrastructure

U.S. House of Representatives

July 19, 2001

John P. Connolly, Ph.D., P.E.
Quantitative Environmental Analysis, LLC
305 West Grand Avenue
Montvale, NJ 07645
201-930-9890
jconnolly@qeallc.com

John P. Connolly, Ph.D., P.E.

I. CONTEXT

Where are we?

Interest in contaminated sediments has increased dramatically within the past 10 years. This is in part due to EPA's success in its first 30 years of existence in dealing with the most pressing environmental needs of the country. Following the intense focus on ongoing sources of pollution, we are now focusing on the next set of problems: pollutants that persist in the environment due to previous releases and due to contributions from ongoing sources that are either diffuse (non-point) or difficult to identify. For example, our recent experience tells us that old and/or inactive industrial facilities and containment structures can be active sources of what might be characterized as relatively small quantities of persistent pollutants, that nonetheless can have a major impact on aquatic sediments, soils, and groundwater.

These problems are complex and difficult compared with many of the problems that have been resolved to date. For example, the solution to the release of untreated sewage to water bodies is obvious: build and upgrade wastewater treatment plants. Contaminated sediments present much more difficult problems in understanding their sources and developing the best solutions. As a society we are currently on the steepest portion of the contaminated sediment management learning curve. The science is young, yet maturing quickly, and our experience base expands yearly. However, we are taking full advantage of neither the scientific understanding that has been developed concerning contaminated sediments, nor the lessons we have learned during the implementation of other large-scale remedial programs, particularly in the field of contaminated groundwater.

The Resource Conservation and Recovery Act (RCRA), the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund), and associated amendments were enacted by Congress on the premise that technology could fully restore contaminated sites. As a result, cleanup goals applied at most contaminated groundwater sites defaulted to the drinking water standards. As a result, the Country embarked on an expensive and ineffective groundwater "pump and treat" initiative. By the early 1990s scientific concerns were raised about the ability of groundwater extraction and treatment technology to achieve the desired cleanup goals. Indeed, a 1994 study by the National Research Council[1] concluded that existing technology is inadequate to restore the vast number of groundwater sites to health-based cleanup levels. Since the early 1990s, groundwater remediation has shifted from aggressive "mass removal" to a risk-based approach, which focuses more on *containment* with the application of natural attenuation and/or other passive treatment systems. That is: control the migration of contaminants and let natural processes such as dilution, biodegradation, and physicochemical destruction control off site migration.

---

[1] National Research Council, 1994. Alternatives for Ground Water Cleanup. National Academy Press. Washington, D.C.

Similar to the groundwater remediation efforts of the 1980s, our current approach to remediating contaminated sediments focuses on eliminating health risks through large-scale dredging and subsequent treatment or, more likely, disposal. Focusing sediment remedial programs on such a "mass removal" paradigm ignores the limitations of dredging technology as well as nature's ability to ameliorate the risks posed by contaminated sediments. As a society we need to apply the lessons we learned from the "pump and treat" phase of our contaminated groundwater program and develop technically feasible and cost effective approaches for addressing contaminated sediments.

We currently "talk the talk" as existing EPA guidance on sediment management recognizes: 1) the importance of source control, 2) the limitations of the existing technology, 3) the need to perform site-specific assessments, and 4) the need to balance short-term impacts against long-term goals as well as costs[2]. However, we are not "walking the walk". A gap currently exists between the formal, documented approach to assessing and remediating contaminated sediments and its implementation. Site managers generally default to large-scale dredging alternatives due to misconceptions regarding natural attenuation processes such as sediment burial and the effectiveness of removal technologies in reducing effective sediment contaminant concentrations, and consequently risks posed by those contaminants.

My Role and Experience

I have been studying contaminated sediment problems since 1978. This study has included government-funded research on various processes critical to the risk posed by these sediments, including sorption, bioaccumulation, toxicity and contaminant fate and transport. I conducted this research as an EPA environmental scientist at the Gulf Breeze, Florida EPA research lab, as a faculty member at Manhattan College, and most recently as an environmental consultant. It has generated over twenty peer-reviewed publications and eight book chapters.

In addition to being involved in research, I have conducted site evaluation and risk assessment studies at numerous contaminated sediment sites. I have been involved in the investigations at most of the large sites in the United States, including:

- Montrose DDT site off Los Angeles
- New Bedford Harbor PCB and metals site in Massachusetts
- Lavaca Bay mercury site in Texas
- Fox River/Green Bay PCB site in Wisconsin
- Grasse River PCB site in New York
- Kalamazoo River PCB site in Michigan
- Hudson River PCB site in New York
- Housatonic River PCB site in Massachusetts
- Penobscot River mercury site in Maine

[2] U.S. EPA, 1998. EPA's Contaminated Sediment Management Strategy. U.S. Environmental Protection Agency. Washington, D.C. April 1998.

These investigations have been conducted on behalf of both government and industry, including: USEPA, NOAA, US Fish and Wildlife Service, General Electric Company, Alcoa, Eaton Corporation and Mallinckrodt, Inc.

II. THE CURRENT PARADIGM

Whether or not remediation of contaminated sediments is warranted depends on the magnitude of direct or indirect health risks to humans or endangered species or to wildlife or aquatic organism populations and the extent of risk reduction that can be achieved by remediation. Common practice consists of a simplistic and conservative determination of the risk posed by the sediments (driven primarily by the precautionary principle) followed by a determination of appropriate remedial technologies. Typically, efficacy of the remedial options has been assumed or given cursory evaluation. In many cases, sediment removal has been presumed to accelerate recovery and to be necessary to prevent the possibility that an increase in risk would occur following some catastrophic event. Evidence indicates that presumptions of efficacy are not always correct. Forty-five percent of the polychlorinated biphenyl (PCB) mass in New Bedford Harbor was removed in 1994 and 1995 through dredging, yet caged mussels have shown no reduction in PCB levels[3]. Twenty-seven percent of the PCB mass in the Grasse River was removed in 1995. Resident fish have shown no positive response, and may have shown a negative response[4]. The lack of efficacy in these cases likely was due to some combination of the following:

1. The targeted sediments may not have been the dominant source of the contaminant loading to the ecosystem. For example, the contributing source may have been widespread low level concentrations of contaminants, rather than definable "hot spots" or the contaminants targeted by dredging were at depth and, consequently, were not contributing to the system or external sources continued contributing contaminant to the system.
2. The removal action itself may have resulted in increased exposure. For example, surface sediment contaminant concentrations may have increased either because all of the higher concentrations in sediments at depth were not removed or because of resuspension or redistribution of higher concentration contaminated sediments (often found at depth) during the dredging operation.

The extent to which either or both of these circumstances are likely to occur can be foreseen using sound science. In fact, postremediation studies in the Grasse River have shown that both arguments are true. The dredged area was not the dominant source of PCBs to the river water and the fish[4] and dredging reduced the average surface sediment

---

[3] U.S. EPA. 1997. *Report on the Effects of Hot Spot Dredging Operations New Bedford Harbor Superfund Site New Bedford, Massachusetts*. USEPA, Narragansett, Rhode Island.
[4] Alcoa. August 1999. *Comprehensive Characterization of the Lower Grasse River*. Report submitted to USEPA Region 2.

PCB concentrations only by one half—from 150 to 75 parts per million (ppm)—and only in a limited area[4]. It should be noted that the interpretation of experience at remediated sites is contentious. Thus, we are proceeding in the absence of a consensus of previous experiences.

The failure to take full advantage of our scientific understanding and interpretative tools is a response to the sheer volume of contaminated sediments and the large number of sites that must be addressed. These facts have led to the reliance on maxims that simplify and expedite site evaluation. The most influential maxims are the following:

- Buried contaminants have a high likelihood of being remobilized (sediments are rarely, if ever, stable)
- Areas of high contaminant mass (i.e., "Hot Spots") control risk

These maxims lead to the conclusion that the removal of contaminant mass, irrespective of whether it is at the sediment surface and currently acting as a source to the water and fish or is buried, will reduce risk. They are combined with a third maxim:

- The risks associated with sediment removal are small and bearable to achieve long-term risk reduction

Unfortunately, none of these maxims are true in general and may be incorrect more often then not. However, they persist because of the lack of communication between researchers expert in the relevant issues and regulators. Science gets simplified, diluted and distorted as it is passed through the various objective and biased groups that lie between the researchers and the regulators.

The lack of in-depth scientific understanding at the regulatory level, combined with the pressure to act, have led to a trial and error approach. Believing that the problem is too complicated to be deciphered accurately, the simple approach is to address the more contaminated sediments and hope that the desired risk reduction is attained. If it is not, a second effort can be attempted. A useful example is the Pine River DDT site in Michigan[5]. Because the contaminated sediments of concern were in an impoundment, it was expected that the natural deposition of sediments entering from upstream would bury the contaminated sediments. When this did not occur as expected, a sediment removal action was implemented beginning in 1999. During the removal action it was discovered that DDT was entering the reservoir from the property of the original source. It is possible, and perhaps likely, that this ongoing source was responsible for the lack of natural recovery. If so, this source has the potential to recontaminate dredged areas and to continue to prevent risk reduction, making the sediment removal pointless. Presumably, further action will be necessary to eliminate the ongoing source. This removal action apparently was undertaken without knowledge of the reasons for the lack

---

[5] Chapman, J. 2001. Pine River DDT sediment site – a nonattenuation site. Presented at US EPA Forum on Managing Contaminated Sediments at Hazardous Waste Sites. Alexandria, VA. May 30 – June 1, 2001.

of recovery, knowledge that I submit could have been obtained by thorough scientific inquiry.

III. A PARADIGM SHIFT IS NEEDED

The recent National Research Council (NRC) report, *A Risk-Management Strategy for PCB-Contaminated Sediments*[6] concludes that decision-making at contaminated sediment sites "often focuses too quickly on defining appropriate remediation technologies." This report advocates a paradigm shift to a focus on comprehensive risk management in which the benefits derived by a remedy and the risks created by that remedy are quantified and contrasted. Such a shift has the benefit of insuring that remedial dollars provide the maximal benefit to all citizens and the potential to reduce the dissatisfaction with the SUPERFUND process common among companies dealing with the Agency.

Accomplishing the paradigm shift requires an expansion of current practice to include *quantitative* examinations of sediment stability (the determinant of the long-term risk associated with leaving contaminants in place) and the impacts on human health and the environment that will occur if the remedy is implemented. There is precedent for both.

Sediment Stability

Sediment stability is one of the most important characteristics of a site that determine the relative risks associated with remediation alternatives. The EPA Contaminated Sediment Management Strategy (CSMS)[7] states: "If contaminated sediments are being transported, or have the potential to be transported, into more critical habitats or are being spread over a wider area where remediation is less technically or economically feasible, active remediation should be performed." The implication is that if sediments are relatively stable, then active remediation may not be appropriate.

Sediment stability is studied in the context of the disposal of dredged material. For example, for open water disposal of dredged material, the following must be considered[8]:

"A knowledge of site characteristics is necessary for assessments of potential physical impacts and contaminant impacts. Information on site characteristics needed for assessments may include the following:

- Currents and wave climate.
- Water depth and bathymetry.

---

[6]National Research Council. 2001. *A Risk-Management Strategy for PCB-Contaminated Sediments.* National Academy Press, Washington, D.C.
[7]U.S. EPA. 1998. *EPA's Contaminated Sediment Management Strategy*. EPA-823-R-98-001..S. EPA.
[8]U.S. EPA and the ACOE. 1992. *Evaluating Environmental Effects of Dredged Material Management Alternatives - A Technical Framework* (EPA842-B-92-008)

- Potential changes in circulation patterns or erosion patterns related to refraction of waves around the disposal mound.
- Bottom sediment physical characteristics including sediment grain-size differences.
- Sediment deposition versus erosion.

Sediment stability is equally important for open water disposal of dredged material and for contaminated sediments. However, sediment stability is not generally considered in the context of contaminated sediments. For example, sediment stability is not considered in the CSMS. The USEPA *Guidance for Conducting Remedial investigations and Feasibility Studies under CERCLA, Interim Final*[9] discusses the evaluation of fate and transport in the remedial investigation: "physical, chemical and/or biological factors of importance for the media of interest", "factors affecting contaminant migration for the media of importance (e.g. sorption onto soils, solubility in water, movement of groundwater, etc.)". These topics can presumably incorporate sediment stability as an issue. However, sediment stability is not brought out as a key issue in the evaluation of contaminated sediments.

Risks of Remedy

The risks of remedy are rarely quantified in common practice. Instead, the assumption is made that the risks associated with not performing the remedy far outweigh the risks associated with a remedy. This approach is inconsistent with regulations and the recommendations of the scientific community:

"Selection of the appropriate remedial option at a contaminated sediment site will be undertaken on a case-by-case basis after careful consideration of the risks a posed by the contaminants to human health and the environment, the benefits of remediation, the short- and long-term effects of implementing the remedial option, the implementability of the remedial option, and the costs of remediation." (CSMS; page 7).

Similarly, according to CERCLA, 42 U.S.C. § 9621(b)(1)(G). EPA must consider "the potential threat to human health and the environment associated with excavation, transportation, and redisposal, or containment". According to 40 C.F.R. § 300.430(e)(9)(iii)(E)(1)-(3), consideration of risks and impacts of remedy implementation to local communities, workers and the environment is required. 55 Fed. Reg. 8,666, at 8,721 (Mar. 8, 1990) states that EPA must consider the "effects on human health and the environment during implementation of the remedial action".

The recent NRC report[6] emphasized the same point: "The evaluation of sediment management and remediation options should take into account all costs and potential changes in risks over time for the entire sequence of activities and technologies that constitute each management option. Removal of contaminated materials can adversely impact existing ecosystems and can remobilize contaminants, resulting in additional risks

[9] (October 1988; OSWER Directive Number 9355.3-01)

to humans and the environment. Thus, management decisions at a contaminated site should be based on the relative risks of each alternative management action."

The impacts of a remedy that require consideration include:

- **Risks to people due to short-term exposure.** No remediation action is perfect; some material is always released, and EPA guidance calls for minimizing such releases. Nonetheless, even with reasonable precautions, sufficient contaminant may be released to the environment to cause human and wildlife exposure to increase temporarily.

- **Risks to communities and workers due to the remedial action itself.** Clean-up activities and transportation of contaminated material to the treatment and deposition site often involve the use of heavy equipment, with its attendant risks of injury to workers and members of the local community.

- **Damage to the environment.** Active remediation of contaminated sediments of necessity affects the ecological communities associated with those sediments. It is often the case that healthy, active ecological communities are present in the contaminated areas in spite of the presence of contamination. Thus, remediation involves the destruction of parts of the community. For example, sediment dredging removes aquatic vegetation, which produces oxygen, provides food for wildlife, provides habitat for fish, and filters particles from the water, and reduces resuspension of sediments. The risks associated with sediment remediation include these immediate effects, which can be extended due to delays in the return of that vegetation.

- **Risks created by long-term storage of excavated sediments.** While much effort has gone into the design of storage facilities for hazardous materials, there is a risk of release of that material to the local environment. Like any structure, storage facilities are designed to withstand certain conditions, not all conditions. For example, hazardous waste landfills typically must be located outside the 100-year flood plain. The fact that they could be subject to flooding in an event that exceeds the 100-year flood must be considered when evaluating the need to remove contaminated sediments because stability cannot be assured in a flood exceeding a 100-year event.

IV. OBSTACLES TO THE PARADIGM SHIFT

Inadequate Guidance for Remedial Project Managers

Consideration of the relative or comparative risks associated with sediment remediation is clearly called for by regulations and scientific opinion. However, while several documents produced by the USEPA guide the performance of risk assessments for contaminated sediments, they do not focus on the risks associated with remediation.

For example, comparative risk assessment is indicated in the document *Assessment and Remediation of Contaminated Sediments* (ARCS)[10]: "Output from the mass balance modeling studies includes estimated contaminant concentrations in water, sediments, and selected fish species following the implementation of proposed remedial alternatives. The comparative risk assessment integrates these outputs to produce estimates of risks for all remedial alternatives under consideration. Thus, the risks associated with each remedial alternative can be compared with the risks associated with the other remedial alternatives, as well as with the baseline risks". This document includes only the changes in risk due to reduction in contaminant concentration, not additional risks due to the remediation itself.

Through the CSMS, EPA has advocated a quantitative scientific approach to site evaluation and remediation. Of particular note are the following two statements:

> "Assessment of sediment contamination and any subsequent steps taken by the Agency to reduce risks should be based on sound science, and, when available, site-specific information."
>
> "Selection of the appropriate remedial option at a contaminated sediment site will be undertaken on a case-by-case basis after careful consideration of the risks posed by the contaminants to human health and the environment, the benefits of remediation, the short- and long-term effects of implementing the remedial option, the implementability of the remedial option, and the costs of remediation."

Although the CSMS presents a sensible strategic approach, it does not provide the needed decision-making framework. The absence of such a framework has been viewed as an obstacle to effective contaminated sediment management[11]. The USEPA Great Lakes National Program Office has proposed a framework as part of the Assessment and Remediation of Contaminated Sediments (ARCS) Program[10]. A ten-step risk management framework was outlined in which the key step was developing quantitative mass balance models to be used in estimating the "… changes in risk, relative to baseline risk, that would result from implementation of the various remedial alternatives evaluated." The framework was implemented in several ARCS studies, but it has not been applied routinely, possibly because detailed guidance was not presented.

Remedial Project Managers Must Balance the Competing Interests of Multiple Stakeholders

Figure 1 presents a schematic of how information flows to Remedial Project Managers. This figure illustrates two important points. The first is that information, demands and expectations that can compete and conflict with policy and guidance

[10]U.S. EPA. 1993. *Assessment and Remediation of Contaminated Sediments (ARCS) Program: Risk Assessment and Modeling Overview Document*. EPA-905-R-93-007.
[11]International Joint Commission. November 19, 1997. *Overcoming Obstacles to Sediment Remediation in the Great Lakes Basin*. White Paper by the Sediment Priority Action Committee, Great Lakes Water Quality Board.

documents flow to the Remedial Project Manager from myriad stakeholders. The second is the Remedial Project Manager is isolated from the research scientists and engineers studying the complex physical, chemical and biological processes that control current and future risk at contaminated sediment sites.

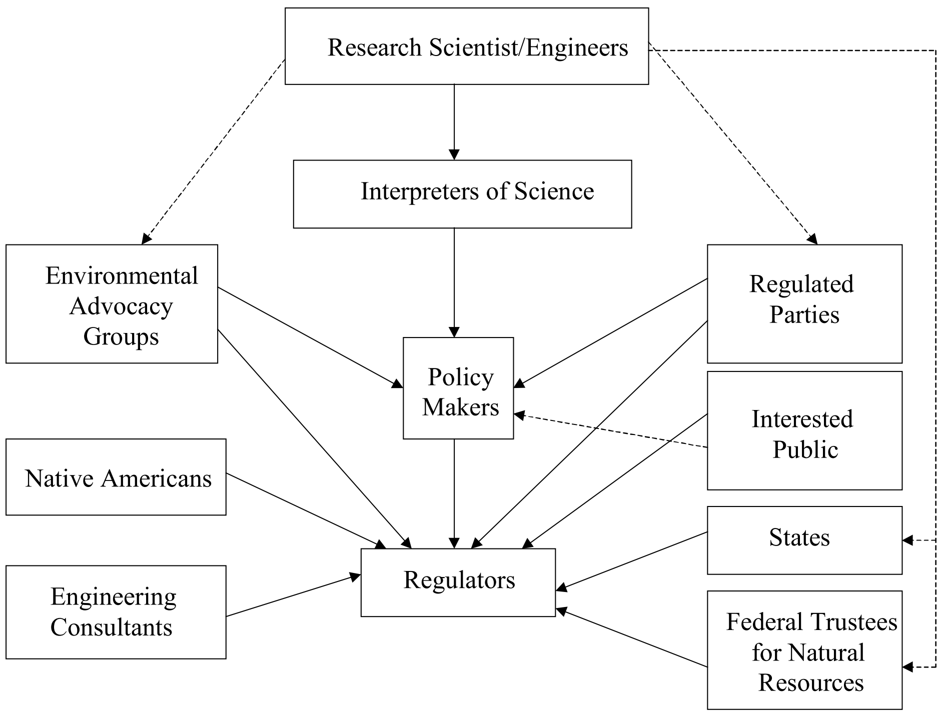

Figure 1. Pathways of information, guidance and advocation from those studying the key scientific issues to the regulators.

Consensus among stakeholders regarding the scientific issues of natural recovery and sediment stability is rare. Further, most stakeholders have a narrow view of the problem, focusing only on a subset of scientific, community and policy issues. For example, it is common for interested environmental advocacy groups to focus on the risk posed by the contaminated sediments and not the risk of remedy nor the risk associated with long-term storage of contaminants. Conversely, local citizens may focus exclusively on the risk of remedy and the risk associated with long-term storage of contaminants.

Remedial Project Managers Lack the Ability to Critique Science

Because of the lack of guidance, complexity of the scientific issues, and the many and contradictory inputs to which the remedial project managers are exposed, they must have the ability to critique the science. However, the typical EPA Project Manager does not have the training to critically evaluate the credibility and utility of the scientific facts and opinions underlying the risk assessments.

V. RECOMMENDATIONS

Efficient and effective implementation of the paradigm shift advocated by the NRC report requires expansion and improvement of the science applied to contaminated sediment problems. This could be accomplished by four initiatives:

- Development of guidance for conducting comprehensive risk assessments
- Development of guidance to objectively evaluate sediment stability
- Establish scientific oversight committees
- Establish an ongoing science training program for remedial project managers

Comprehensive Risk Assessment Guidance Documents

Guidance documents are needed that provide a detailed decision-making framework that can be applied by remedial project managers and the technical staff conducting the site evaluation. The documents should address the quantitative prediction of the risk imposed by the contaminated sediments, the change in risk due to natural recovery practices and active remediation, the risk caused by the remedy and the risk resulting from the long-term storage of excavated sediments. These documents should be more than general guides. They should detail specific procedures for evaluation of each of the scientific issues that govern risk at the site.

Guidance for Objective Evaluation of Sediment Stability

Because sediment stability is the issue of most significance in evaluating the risk associated with leaving contaminated sediments in place, and because it is complex and highly site-specific, detailed guidance in its evaluation is needed. This guidance should provide specific procedures for the collection and interpretation of data to examine stability and the development and application of models to predict stability. Development of this guidance will have to be preceded by an objective scientific review of sediment stability in order to synthesize the experience of individual groups and researchers.

Scientific Advisory Committees

Given the complexity associated with the evaluation of contaminated sediment sites and the divergence of scientific opinion that frequently exists among stakeholders, it is recommended that the remedial project managers have access to advisory committees that could be brought to bear on large or particularly complex sites. These committees should be structured to overcome some of the limitations apparent in the current peer review process, particularly the lack of an in-depth understanding of the site and the project. Therefore, they should be formed at the beginning of a project so that the members acquire knowledge of all aspects of the work and the scope and extent of existing information. They should meet fairly frequently with the project team to provide review and advice. Meetings should be open with a free exchange of information among all interested parties. The committees should have expertise in the major areas of science being investigated in the project.

Ongoing Science Training Program

To insure that remedial project managers have understanding of the scientific issues important at sites (e.g., sediment stability, sediment transport, bioaccumulation, etc.) sufficient to assimilate, interpret and respond to the claims made by the various stakeholders and the project technical staff, it is recommended that an ongoing education program be developed. This program should consist of one-day seminars held at regular intervals and devoted of particular topics. These seminars would provide an overview of the scientific issues, a summary of the impact of site-specific factors on the subject physical, chemical or biological processes and approaches for developing the information needed for the comprehensive risk assessment. They would be organized by EPA Headquarters and staffed by in-house research scientists and experts brought in from academia, industry and consulting.